Claims

We claim:

1. A method of increasing the hydrophilicity of a polymer surface, comprising the steps of:

   a. providing a polymer having a nonfunctionalized surface;

   b. exposing said nonfunctionalized surface to a plasma; and

   c. exposing said nonfunctionalized surface to a reactive gas;

   whereby a functionalized polymer surface with increased hydrophilicity is obtained.

2. The method as recited in Claim 1, wherein step b and step c occur substantially simultaneously.

3. The method as recited in Claim 1, wherein step b occurs before step c.

4. The method as recited in Claim 1, wherein said polymer is a poly-halogenated polymer.

5. The method as recited in Claim 4, wherein said poly-halogenated polymer is selected from the group consisting of poly-n-fluoroethylene, poly-n-fluoropropylene, polyvinylidenedifluoride, polyvinylchloride, and combinations thereof.

6. The method as recited in Claim 5, wherein n is selected from the group consisting of mono, di, tri, and tetra.

7. The method as recited in Claim 1, wherein said polymer is polypropylene or polyethylene.

8. The method as recited in Claim 1, wherein said polymer comprises polystyrene, polycarbonate, and acrylic polymers.

9. The method as recited in Claim 1, wherein said plasma is selected from the group consisting of O_2, N_2, N_2O, air, the noble gases, and combinations thereof.

10. The method as recited in Claim 1, wherein said reactive gas is selected from the group consisting of oxide, halide, hydrazine, arsine, and combinations thereof.

11. The method as recited in Claim 10, wherein said oxide comprises SO_x, CO_x, NO_x, halogen oxide, and combinations thereof.

12. The method as recited in Claim 11, wherein said halogen oxide is selected from the group consisting of ClO_2, BrO_2, IO_2, $HClO_2$, and combinations thereof.

13. The method as recited in Claim 10, wherein said oxide is selected from the group consisting of SO_3, SO_2, CO_2, NO, NO_2, and combinations thereof.

14. The method as recited in Claim 10, wherein said halide is selected from the group consisting of Cl_2, Br_2, I_2, and combinations thereof.

15. The method as recited in Claim 1, further comprising the step of washing said functionalized polymer surface with a solvent thereby removing a residue from said reactive gas.

16. The method as recited in Claim 15, wherein said solvent comprises water.

17. The method as recited in Claim 1, further comprising the steps of exposing said functionalized polymer surface to a liquid-phase reactant and heating said liquid-phase reactant to induce growth of a metal oxide on said functionalized polymer surface.

18. The method as recited in Claim 17, wherein said liquid-phase reactant is selected from the group consisting of metal alkyls, metal organics, metal oxide solutions, and combinations thereof.

19. The method as recited in Claim 17, further comprising the step of treating the functionalized polymer surface with a NaOH solution after growth of said metal oxide.

20. The method as recited in Claim 1, wherein said polymer comprises non-planar shapes.

21. The method as recited in Claim 20, wherein said non-planar shapes comprise complex, three-dimensional geometries.

22. The method as recited in Claim 21, wherein said complex, three-dimensional geometries are polymer packing materials, contact lenses, or biological implants.

23. The method as recited in Claim 1, wherein said functionalized polymer surface comprises said nonfunctionalized polymer surface with functional groups selected from the group consisting of acidic, basic, and neutral functional groups attached thereon.

24. The method as recited in Claim 23, wherein said acidic functional group is selected from the group consisting of sulfonate, phosphate, carboxylate, and combinations thereof.

25. The method as recited in Claim 23, wherein said basic functional group is selected from the group consisting of amine, hydroxyl, and combinations thereof.

26. The method as recited in Claim 23, wherein said neutral functional group is selected from the group consisting of alcohol, thiol, and combinations thereof.

27. A polymer having a surface treated in accordance with the process of Claim 1.

28. A polymer packing material with increased hydrophilicity comprising a plurality of surfaces, said plurality of surfaces functionalized by exposure to a plasma and to a reactive gas.

29. The polymer packing material as recited in Claim 28, wherein said functionalized plurality of surfaces has a plurality of functional groups thereon.

30. The polymer packing material as recited in Claim 29, wherein said plurality of functional groups is a sulfonated functional group.

31. The polymer packing material as recited in Claim 28, wherein said plurality of surfaces has a plurality of functional groups thereon and a metal oxide coating over said plurality of functional groups.

32. The polymer packing material as recited in Claim 31, wherein said metal oxide coating comprises an iron oxide coating.

33. A polymer material having a characteristic water contact angle, wherein the improvement comprises :

a functionalized surface on said polymer material having a modified water contact angle less than said characteristic contact angle.

34. The polymer material as recited in Claim 33, wherein said polymer material is polypropylene or polyethylene.

35. The polymer material as recited in Claim 33, wherein said polymer material comprises a poly-halogenated polymer.

36. The polymer material as recited in Claim 35, wherein said poly-halogenated polymer is selected from the group consisting of poly-n-fluoroethylene, poly-n-fluoropropylene, polyvinylidenedifluoride, polyvinylchloride, and combinations thereof.

37. The polymer material as recited in Claim 36, wherein n is selected from the group of mono, di, tri, and tetra.

38. A polymer material comprising at least one functionalized hydrophilic surface.